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AR National Research Program

NRP NO. 20390 Poultry production

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PREFACE

This document is one of the SEA-AR National Research Programs (SEA-AR-NRP's). These programs provide the basic plans for research in the Science and Education Administration, Agricultural Research (SEA-AR). The SEA-AR-NRP's and the SEA-AR Special Research Programs (SEA-AR-SRP's) are a part of the SEA-AR Management and Planning Systems (MAPS). The plans identify national research objectives, describe methods for achieving these objectives, and provide the accounting and reporting system by which these program areas are planned and managed.

Each of the SEA-AR National Research Programs and Special Research Programs outlines a 10-year plan that describes current technology and new technology expected in the 10-year period. The plan includes approaches to research and benefits expected to result from new technology. The Special Research Programs facilitate research planning and management in those exceptional circumstances where special funds are involved or a different kind of research management is needed. They provide the same general type of information as the SEA-AR-NRP's. Both types of research programs were prepared by the National Program Staff with the cooperation of Regional Staffs and Line Managers, Technical Advisors, Research Leaders, and other scientists.

These research plans will be used for a variety of purposes. They serve to link SEA-AR research projects to major program areas involving several agencies within the USDA program structure. SEA-AR-NRP's and SEA-AR-SRP's identify important national problems and describe plans for achieving technological objectives. They provide justifications for current research activities and the basis for funds for future research. They serve as the basis for program reports and for the Agency's accounting system. They also improve the communication between scientists and management, between research managers and staff scientists, between SEA-AR and other research organizations, and between USDA and other departments, the private sector, and Congress.

These documents are dynamic statements of SEA-AR research plans and, as new knowledge is developed, they will be continually updated to reflect changes in objectives and research approaches.

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SEA-AR-NRP No.: 20390
USDA Program No.: 22-678

POULTRY PRODUCTION

Technological Objectives

Cross Reference by Technological Objective to Other NRP's

Cross reference entire NRP to 20450, Control of Poultry Diseases

TO1	20350	Dairy production
	20370	Swine production
TO2	20370	Swine production
TO3	20350	Dairy production
	20370	Swine production
TO4	20400	Livestock structures and equipment
		SRP on energy
	20790	Preventing pollution & improving the quality of soil, water & air
	20450	Control of poultry diseases
TO5	20470	Toxicology of chemicals & poisonous plants
	20820	Residues & additives-foods & feeds
	20840	Toxic constituents of foods & feeds

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CATALOGING PREP

SEA-AR-NRP No.: 20390
USDA Program No.: 22-678

POULTRY PRODUCTION

I INTRODUCTION

Considerable advancement has been made in poultry production technology in the last 30 years. However, significant improvements can still be made in the efficiency of production, efficiency of nutrition, management practices and systems, and efficiency of producing quality products. Under this NRP, both basic and applied research are conducted on the above approaches to improving the efficiency of production and quality of poultry products. Included are chicken and turkey meat and chicken eggs. In value, poultry constitutes about 7.5% of all agricultural commodities and 17% of livestock commodities. Thus, improving efficiency of poultry production and quality of poultry products is a significant part of the USDA mission to improve agricultural production efficiency. It also relates to the missions of marketing efficiency research, research to expand agricultural exports, research on conservation and use of land and water resources and maintaining environmental quality, and it relates to a lesser extent to many other missions. It is a part of the operating goal "new knowledge to increase crop and livestock productivity."

II SEA-AR NATIONAL RESEARCH PROGRAM SUMMARY

A Current Technology. Poultry production is a highly intensive industry where farms can have 100,000 birds the same age on the premises at the same time. However, the bulk of poultry is produced in smaller units by individual farmers usually on a contract basis. Most pullets for commercial production are reared on the floor and transferred to cages at maturity. Broilers and broiler breeders are reared in houses on the floor and most turkeys on range. Some current industry figures are in the following table.

Commodity	Annual reproduction rate: Eggs	Annual reproduction rate: Hatch	Duration of lay	Body weight of breeding female	Nutrition efficiency	Market weight	Time to reach market weight		Downgrades or cracks
	(No.)	(%)	(Months)	(Lbs.)	(Lbs. feed/ lb. produced)	(Lbs.)	(Days) ♀	(Days) ♂	(%)
Broiler-type	155	82	10	7.0	2.0	3.8	55	48	36
Egg-type	235	90	12	4.2	2.4[a/]	N/A	N/A	N/A	7.2[b/]
Turkeys	82	70	5	21.0	3.6	18-24	119	147	24

a/ Lbs. feed/lb. eggs produced
b/ % of eggs cracked

Diets contain primarily corn and soybean meal and very few wastes or by-products. Agricultural chemicals and insecticides occasionally contaminate products. The level of mycotoxins in feed and products is unknown. Brooding requires additional heat, usually propane, and there is frequently no environmental control because many houses have insufficient insulation and open sidewalls with adjustable curtains.

Litter and waste are usually spread on the land and, if stored, are piled on the ground. Although there is mechanized collection, quality control and packaging of eggs, harvesting broilers and turkeys requires manual labor.

B Visualized Technology. Farm size will continue to increase until single premises will house over 1 million birds of similar age. Egg-laying chickens will be reared in cages for their entire life. There will be an increase in the number of broilers and broiler breeders that will be reared in cages and the number of turkeys that will be reared in confinement. Estimates of figures achievable in the next 10 years are in the following table.

Commodity	Annual reproduction rate		Duration of lay	Body weight of breeding female	Nutrition efficiency	Market weight	Time to reach market weight		Downgrades or cracks
	Eggs	Hatch							
	(No.)	(%)	(Months)	(Lbs.)	(Lbs. feed/ lb. produced)	(Lbs.)	(Days) ♀	♂	(%)
Broiler-type	165	85	11	5.5-7.5	1.8	4.2	50	43	32
Egg-type	275	93	14	3.6	2.2	N/A	N/A	N/A	6.9
Turkeys	110	75	7	21.0	3.4	20-26	112	140	21

Fossil fuel energy necessary for production will be reduced to 50%. Some of the fossil fuel energy will be replaced by other forms of energy, e.g., solar. The proportion of feed not usable as human food will increase in poultry diets and up to 90% of poultry waste will be refed in ruminant diets. Systems for rearing and harvesting meat-type poultry will be developed which require 50% less labor. Feed and poultry products very rarely will be contamined with agricultural chemicals and mycotoxins.

C Consequences of Visualized Technology. Improved efficiency of poultry production will give the farmer better control of his operation and the consumer will receive the maximum amount of highest quality product for his money. Because the ability to supply poultry meat and eggs far exceeds the demand, profits to the farmer will depend on the relationship of demand to supply. In addition, consumer confidence in, and satisfaction and acceptance of, poultry and poultry products will be increased. Newer production and processing methods will result in a greater use of highly

automated equipment which may change labor patterns. The above will make possible the expansion of a source of low cost, high quality protein content food for the consumer. Additional benefits will be a reduced pollution of the environment and better utilization of resources. No significant adverse consequences can be identified.

D Total Potential Benefits

	Reduced Current Loss			Potential Improvement			
Technology	Broiler	Layer	Turkeys	Broiler	Layer	Turkeys	Total
Reproduction	4.7[a/]	3.9	1.4	29.6	31.3	8.2	79.1
Nutrition	4.7	5.9	1.4	44.2	46.9	12.3	115.4
Genetics	7.0	3.9	2.0	44.2	31.3	8.2	96.6
Management	7.0	5.9	2.0	44.2	47.0	12.3	118.4
Quality	4.7	3.9	1.4	14.8	31.3	8.2	64.3
Total	28.1[b/]	23.5[b/]	8.2[b/]	177.0[c/]	187.8[c/]	49.2[c/]	473.8

a/ Millions of dollars.
b/ 15% (60% of 25%) of losses from mortality, condemnations and downgrading.
c/ 6% of value of industry.

E Total Research Effort

		Current Support		Expanded Support	
TO	Short Title	SY	$ Gross (000)	No. SY's Added	Total SY's
1	Reproduction	4.5	582	2	6.5
2	Nutrition	5.8	801	2	7.8
3	Genetic capacity	3.9	386	2	5.9
4	Management	1.0	107	2	3.0
5	Quality	2.8	323	2	4.8
	Total	18.0	2199	10	28.0

NOTE: The expanded support level reflected in this National Research Program represents Staff's views as to the additional level of staffing that can be effectively used in meeting the long-term visualized objectives for this program. These do not reflect commitments on the part of the Agency.

III TECHNOLOGICAL OBJECTIVES

Turkeys--The turkey industry has changed substantially in the past 40-50 years. Production rose from 20 million birds in 1953 (3) to almost 140 million birds in 1976 (6). Per capita consumption rose from 1.7 pounds in 1935 to 9.2 pounds in 1976. The character of the turkey industry also changed over the same period. There were almost 19% fewer turkey farms in 1974 compared with 1969 and the average number sold per farm was nearly 49% higher (2). Contract production increased from 21% of total production in 1955 to 52% in 1975. The number of processing plants slaughtering more than 15.6 million pounds more than doubled from 1962 to 1972 while the number of processing plants slaughtering less than 5.2 million pounds annually fell to less than half of the 1962 level (3).

The turkey industry has followed the trends of the broiler industry in changes in marketing structure, size of farm, production technology, and demand increases. However, the turkey industry is not yet as highly integrated as the broiler industry. It also has more producer cooperatives.

Processed turkey products, such as turkey rolls, roasts, ground turkey, and luncheon meats, have expanded the market for turkey and now account for over half of the turkey produced. The year-round processing and consumption of these processed products have helped reduce the seasonality of demand; thus, the fourth quarter per capita consumption of turkey fell from 57.4% of total annual consumption in 1963 to 46.1% in 1972 (3). The demand for turkey, particularly processed turkey products, is expected to continue to increase in the future.

Turkey production should continue to increase, but it will do so at a slower rate since many of the economies of scale and technology have already been captured. Feed conversion for 12-14 pound hens has been lowered to nearly 3 pounds of feed per pound of live turkey and may be reduced even further. Through a combination of genetic, nutritional, and management developments, feed conversion may be lowered to 2.5 pounds or less for small broiler-fryer-roaster turkeys and to less than 3 pounds for the heavier hens and toms. However, the ability of technological advances to reduce costs in the future will be limited by higher energy costs and the costs of meeting environmental standards in production and processing.

Broilers--Broilers are young chickens 6 to 10 weeks of age. U.S. broiler production has risen from 34 million birds in 1934 to 3.3 billion birds in 1976 (2, 6). Per capita consumption of broilers rose from 0.5 pounds in 1934 to 43.3 pounds in 1976 (1, 6). These tremendous gains in production and consumption resulted from new production and marketing technologies and changes in the economic structure of the industry--resulting in prices to consumers increasing less than those for competing meats. Broilers were 16.9¢/lb. in 1960 and 23.6¢/lb. in 1976 (6). A general rise in real per capita disposable income also has been a factor in increasing broiler meat consumption.

Since the 1930's, the broiler industry has changed gradually from one characterized by small independent farm flocks and small processors to an efficient, highly integrated industry. Over 90 percent of broilers are produced under contract. A typical production unit now consists of a hatchery, a feedmill, a processing plant, a field service and management staff, and 150 to 300 contract growers. The economies of scale gained in processing and other activities associated with large integrated firms, as well as the improved efficiency in broiler production, have allowed the broiler industry to hold down or decrease many production and marketing costs. Feed costs represent 72% of total costs and chick costs 14% in 1970-1976 (1). Whereas it took 25 hours per 100 birds 1935-1939, it took only 0.9 hours in 1972-1976 (7).

Advanced in production technologies through genetic research and development, improvements in poultry nutrition, and improved management practices have enabled the broiler industry to produce a 3.8 pound live broiler in 7-8 weeks instead of the 12-14 weeks of 20 years ago and with a feed conversion near 2.0 pounds of feed per pound of live broiler compared to 4 pounds in 1940 (1).

Tremendous advances have been made in the past 20 years in converting plant and animal waste protein and energy into a nutritious animal protein product. It will not be easy for the scientific and technological community to match these advances in the future. Advances can be made, however, in the use of poultry waste as a feed ingredient, improved management practices and equipment to conserve energy, new preservation methods, further genetic improvements, a better physiological understanding, vaccines, etc. Such improvements could further reduce cost of production and marketing. Fuel consumption may be reduced. Alternate sources of energy may exist. Use of poultry litter as a feed for ruminants may provide an added source of income.

Although opportunities for further reducing the total cost of producing and marketing are limited, the production efficiency of broilers should provide a major source of animal protein in the future.

Eggs--The egg industry, like the broiler and turkey industries, has undergone many structural and technological changes in the past 25 years. In the 1950's, 400 million layers produced about the same number of eggs now produced by less than 270 million layers. These are on fewer but larger farms, thus, the number of farms with hens and pullets has declined 32% between 1969 and 1974 and the number per farm increasing 41%.

Egg production has not risen as dramatically as broiler or turkey production since the aggregate demand for eggs has been declining for more than two decades. Per capita egg consumption fell from 364 eggs per year in 1950 to 272 in 1977 resulting in a net decline of 92 eggs per year per person from 1950 to 1977. Per capita consumption of processed eggs rose from 25 in 1950 to 37 in 1977 (2).

Advances in production and marketing technology have made it possible to produce and market a higher quality product while maintaining a lower retail price from 1951 through 1972. (If these prices were deflated, the reduction in cost to the consumer would be even more apparent.) The annual rate of lay per layer increased from 174 in 1950 to 235 in 1977 (2). The number of eggs sold per farm increased from 1,600 dozen to 13,600 dozen from 1954 to 1968 (7). The industry has become more vertically and horizontally integrated and many large fully integrated production, assembly, and processing units now exist in all regions of the United States. Over the past two decades, output expanded fastest in the Southern and Western regions. Contract egg production has also increased.

The improved production of layers has led to better feed conversion, increased egg production, and improved interior quality. Poor shell quality continues to be one of the major causes of economic loss, particularly at the farm and retail level.

Management practices and production faciities have changed considerably with the advent of caged production and with mechanized feeding and egg collection. Whereas it took 240 hours of labor per 100 layers and 1.5 hours per 100 eggs produced in 1945-1949, it took 70 and 0.3 hours in 1972-1976 (6). The seasonal production pattern has also changed from that of the 1950's when monthly late winter and spring production was as much as 60% greater than early fall production. Monthly production is now fairly constant. This has come about largely because of better, environment-controlled housing that uses more insulation, improved ventilation techniques, and improved lighting practices. Further improvement is possible through even better temperature control in poultry houses.

Processing and packing operations are generally located in producing areas. Collecting, grading, processing, cartoning, and labeling have been mechanized; thus eggs can be processed quickly and efficiently in large-scale plants with less labor. The egg breaking and processing industry has changed from a seasonal surplus egg operation to an established year-round secondary demand for eggs. It now uses about 6% of the annual egg production (2). The size of the egg breaking plants has also increased.

As the cost-reducing effects of new production and marketing technologies diminish, the egg industry may find itself in periodic cost-price squeezes, particularly if egg demand continues to decrease. The potential decreases in feed conversion to perhaps less than 4 pounds of feed per dozen eggs and additional production and processing efficiencies may be more than offset in the future by higher energy, labor, and material costs.

The genetic capacity for reproduction of egg laying chickens and the genetic capacity for meat production of broiler chickens and turkeys exceeds that of any other major farm animal; however, there is still room for further improvement. Nutritional and management systems are geared to the availability of low cost feed and energy and there is ample room for

increase in efficiency of utilization of these resources. As nutritional and management systems change and as pollutants appear in the food chain, there is a continual struggle to maintain and improve quality of poultry products.

Calculation of Potential Benefit. Potential benefits comprise reduction of current losses from deaths, condemnations, downgrading, etc., and gains in production efficiency through better feed conversion, faster growth rate, increased egg production, etc. The procedures for calculating these benefits were as follows: The cost of current losses to poultry production was calculated for (a) death, condemnation and downgrading of broilers, (b) death and condemnation of layers and egg cracks, and (c) death, condemnation and downgrading of turkeys. The total costs were allocated to various disease and production factors. The 1976 figures for broilers were multiplied by 1.54, for layers by 1.17 and for turkeys by 1.51, factors which represent increases in production estimated by ERS projections over 10 years in "1985 Agricultural Direction," the Farm Index, USDA, February 21, 1973. This yielded the total loss using current technology in 1986 and loss in approximated total 1988. It was estimated that on the average, the loss could be reduced by 25% by using new technology in place of current technology in 1988. To these benefits were added the potential benefits to be obtained by increasing the efficiency of production; it was estimated that efficiency of production would increase 10% by 1988 and that 60% of this was due to production factors and 40% other factors. The losses and potential increases were assigned to TO's as follows.

Proportion of Loss for 1978 and Potential Increased Production with 1988 Technology Assigned to Different TO's

	% of Losses			% of Increase		
TO	Broiler	Layer	Turkey	Broiler	Layer	Turkey
1 Reproduction	10	10	10	10	10	10
2 Nutrition	10	15	10	15	15	15
3 Genetics	15	10	15	15	10	10
4 Management	15	15	15	15	15	15
5 Quality	10	10	10	5	10	10
6 Other	40	40	40	40	40	40
Total	100	100	100	100	100	100

The sum represents the benefits obtainable from decrease in losses due to death and condemnation and potential increase in production by 1988.

The total value of production and the death losses were obtained from Agricultural Statistics 1977, United States Department of Agriculture, Government Printing Office, Washington, DC 20402, and are in the table on page 8.

Base Statistics 1978 (1976 data)

Commodity	Production (Million)	Value at Start ($ each)	Death Loss (%)	Value at End ($ each)	Condemnations: Antemortem (% live-weight)	Condemnations: Postmortem (% ready to cook)	Downgrade or Cracks (%)	Loss Percent (c/lb or doz)	Value of Production ($ million)
Egg-type chickens									
Hatch-20 wks 2/	492♀♂ 3/	0.38	7.5 8/	1.70 5/	N/A	N/A	N/A	N/A	644
20-80 wks	271♀ 4/	1.70 5/	11.0 9/	0.67	N/A	N/A	N/A	N/A	145
Broilers	3,283	0.14	6.0	0.90	0,322	1.799 11/	36	4	2,950
Eggs	64,511	N/A 6/	5.0 10/	0.58 12/			7.2	19 12/	3,133
Turkeys	140	1.00 7/	8.1	5.89	0.244	2.267 11/	24	3	825
								TOTAL	7,053

1/ All data from Agricultural Statistics 1977 unless otherwise indicated
2/ Raised
3/ Hatched during 1976 (Jan-Dec)
4/ Includes male breeding stock
5/ Value from all chickens
6/ N/A = Not applicable
7/ Estimated by National Turkey Federation
8/ Raised as % of hatched
9/ From Poultry and Egg Situation
10/ Egg breakage
11/ Condemned New York dressed converted to ready to cook with data from Mountney 1966
12/ Value/dozen.

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III.1 Improve efficiency of reproduction

The value of the poultry industry by 1980 will be over $10 billion. It is estimated that the per capita consumption of poultry products will continue to increase because the efficiency in production and processing is providing consumers with a low-cost source of protein for the human diet. In addition to increases in utilization of poultry in the U.S., marked increases have occurred in foreign sales.

Improvement in reproductive efficiency has great potential in the economics of the poultry industry. It is estimated that almost $200 million is lost annually as a result of poor egg production. Also, problems associated with fertility and hatchability cost the industry an additional $300 million annually. These problems are further compounded by rising production costs primarily in the form of energy and feed. Therefore, every effort must be made to develop research programs which meet the needs of today's poultry industry. Problems such as low egg production, poor egg shell quality and low fertility-hatchability require the combined efforts of scientists in such disciplines as genetics, nutrition and physiology. Research must be continued to determine the most effective techniques for maximum short-time and long-time improvement.

A Current Technology. Increasing the efficiency of producing eggs can be accomplished by increasing the number of eggs laid during a 365-day period or by increasing the productive life of poultry. At present, turkey breeder hens have an economically productive life of about 5 months, broiler breeder hens 10 months, and egg-type laying and breeder hens 12 months. The pattern generally is that they come into production and then lay fewer and fewer eggs until it is no longer economical to retain them. It is reasonable to assume that the key to reaching the current industry objectives of extending the rate of duration of egg production lies in a better understanding of how the sequence of changes in the reproductive life of the hen are regulated and, consequently, of how changes from a desirable to an undesirable stage of reproduction can be avoided. An increased understanding of the basic mechanisms controlling ovulation and oviposition is needed.

Understanding the events which terminate egg production of normal producing hens is critical. For example, a good turkey hen will lay a 10 to 15 egg clutch, pause one to three days, and then lay another large clutch. One to three days is considered a pause which is just a short resting period before starting another clutch. A hen which takes a six-day rest period and shows "broody" (nesting behavior) tendency will terminate production 10-21 days. Control of the broody problem is by far the largest single factor which affects the profit picture of a healthy turkey laying flock. Research efforts should be focused on the relationship between persistent nesting and the onset of follicular atresia in broody hens. Methods for early detection and treatment of broodiness are needed which will circumvent collapse of the ovary and the consequent pause in egg production until new follicles have developed.

Hatchability of fertile eggs from broiler-type chickens and turkeys is much lower than hatchability of eggs from layer chickens (broilers, 82%; turkeys, 70%; layers, 90%). The loss of income that breeder hen flock owners suffer from death of embryos during incubation is substantial. Proper flock and hatchery management practices can control, to a certain degree, many of the causes of embryonic death. However, many embryos die because of detrimental changes in the chromosomes, and because of our present state of knowledge we simply must live with the problem. Poor egg strength and texture, especially in older hens, continue to plague the industry. The overall effect of poor egg shell quality cost the industry about $250 million annually. The specific relationship of poor egg shell quality to poor hatchability has been well documented but little information has been gathered on the mechanisms associated with the phenomenon. Research on this problem must be continued and involve the combined effort of scientists in such disciplines as genetics, nutrition and physiology.

Nearly all turkey hens are bred artificially and this practice is costly, primarily in terms of labor. Depending on the artificial insemination (A.I.) program, it requires a trained crew of 5 to 10 people. However,

the cost of A.I. can be lowered in several ways--e.g., refining and mechanizing the techniques and equipment, developing methods to insure maximum semen output from the breeder male and by improving methods of extending and preserving semen. Artificial insemination of broiler breeder stock in cages offers a potential increase in body weight. By intensive selection of the male lines, 0.6 pound per generation is possible. Caging of both turkey and broiler breeders offers the advantages of reduced 1) capital cost per hen housed, 2) number of contaminated eggs, 3) overall labor cost, and 4) fixed and variable costs.

If improvements in efficiency of reproduction are desired, the optimal nutritional plan as well as the use of satisfactory management practices to minimize stressful conditions during the prebreeder and breeder period must be established. Nutritional requirements for poultry breeders are continuously being reexamined because of the changes in breeding and management of the modern bird. Active research areas are needed to determine what is the proper weight or stage of maturity of a bird at lighting, daily protein requirement, dietary energy levels, level of feed restriction, alternative dietary protein sources, etc., for both males and females. A further understanding of the effects of temperature, light and humidity are important to minimize stress during both the breeder and prebreeder period.

The following can be attained with current technology.

Commodity	Annual reproduction rate		Duration of lay	Body weight of breeding female	Nutrition efficiency	Market weight	Time to reach market weight		Downgrades or cracks
	Eggs	Hatch							
	(No.)	(%)	(Months)	(Lbs.)	(Lbs. feed/ lb. produced)	(Lbs.)	(Days) ♀	♂	(%)
Broiler-type	155	82	10	7.0	2.0	3.8	55	48	36
Egg-type	235	90	12	4.2	2.4	N/A	N/A	N/A	7.2
Turkeys	82	70	5	21.0	3.6	18-24	119	147	24

B <u>Visualized Technology</u>. Develop new technology that will result in an increase in the number of chicks and poults from chicken and turkey breeding stock. This will come from increased numbers, increased hatch, and increased duration of lay as shown in the following table.

Commodity	Annual reproduction rate: Eggs	Annual reproduction rate: Hatch	Duration of lay	Body weight of breeding female	Nutrition efficiency	Market weight	Time to reach market weight		Downgrades or cracks
	(No.)	(%)	(Months)	(Lbs.)	(Lbs. feed/ lb. produced)	(Lbs.)	(Days)		(%)
							♀	♂	
Broiler-type	165	85	11	5.5-7.5	1.8	4.2	50	43	32
Egg-type	275	93	14	3.6	2.2	N/A	N/A	N/A	6.9
Turkeys	110	75	7	21.0	3.4	20-26	112	140	21

C Research Approaches. Basic and applied research is necessary to determine the best systems for breeding, feeding, and managing poultry to improve the efficiency of producing eggs and meat. The following approaches identify research needed to improve reproductive efficiency. They are not listed by priority.

1 Improve egg and semen production

a. Identify the endocrine and neuroendocrine mechanisms regulating egg production and broodiness. (NER, APL, Beltsville, Md.)

b. Determine whether rate of lay is related to age at sexual maturity. (NCR, Lafayette, Ind.)

c. Characterize the behavioral patterns associated with the onset of broodiness. (NER, APL, Beltsville, Md.)

d. Develop sensitive and specific assays for identifying and measuring relevant pituitary and gonadal hormones. (NER, Beltsville, Md.)

e. Determine nutrient requirements of caged breeder hens for maximum egg production. (NER, NRNL, Beltsville, Md.)

f. Determine the effect of the growing diet on subsequent feed utilization during the laying period. (NER, NRNL, Beltsville, Md.)

g. Develop management systems (diet, lighting schedules, environment, etc.) favoring optimum production of semen. (NER, APL and NRNL, Beltsville, Md.)

h. Determine the effect of air condition (temperature and humidity) and its interaction with nutrition on egg production. (NER, NRNL, Beltsville, Md.)

2 Improve fertility and hatchability

a. Study the factors which influence the fertility, transport and storage of spermatozoa *in vivo*. (NER, APL, Beltsville, Md.)

b. Determine the sequence of events associated with fertilization. (NER, APL, Beltsville, Md.)

c. Develop methods to preserve semen without critical loss of fertilizing capacity. (NER, APL, Beltsville, Md.)

d. Study the relationship of the hen's diet to the energy reserves of the embryo on the hatch and survival of turkey poults. (NER, NRNL, Beltsville, Md.)

e. Determine the relationship of egg shell quality, stage of egg production to hatchability of eggs. (NER, NRNL, Beltsville, Md.; PRL, Georgetown, Del.)

D Consequences of Visualized Technology

1. Reduce the farm production costs of poultry meat and eggs.

2. Reduce the cost of poultry meat and eggs to the consumer and provide a low cost, high quality product for the consumer.

3. Increase the consistency of both quality and quantity of production of poultry meat and eggs and thereby provide the producer with a more consistent return.

4. Reduce protein requirements of poultry.

5. Reduce shell breakage in market channels.

6. Develop new knowledge from research in basic physiology and genetics which will contribute to technological advancement in other farm animals and man.

7. Increase consumer satisfaction and acceptability of poultry and egg products.

8. Reduction in the number of breeder females sold.

E Potential Benefits. The need for increased food production is critical and it is expected that poultry production will play a key role in the race against food shortages. Research must continue not only for the purpose of improving total production but also to develop ways of increasing production efficiency and at the same time improving the quality of poultry. Continued research efforts to improve total egg

production and, at the same time, reduce problems associated with egg shell quality are imperative. If market egg production could be increased by 5% without increasing the number of layers, an additional 3.2 billion eggs could be produced annually resulting in $138 million additional gross income. Similarly, if both hatching egg production and hatchability were increased by 5%, the production of poultry meat (chicken and turkey) would increase an additional 145 million pounds and gross the industry about $175 million.

The additional gross income of over $300 million to the industry benefits both poultry producers and consumers. With feed prices increasing at an alarming rate, increases in fertility and hatchability could drastically reduce the operating costs of primary breeders by reducing the need to keep large genetic pools. Improvements in the area of artificial breeding and frozen semen would enable breeders a) to get more genetic advancement per generation through higher selection pressures, b) to have a more precise evaluation of genetic improvement, and c) to develop worldwide markets. Poultry producers will benefit from increases in egg production in the form of reduced breeder chick or poult costs and reduced broiler and market egg costs. The amount of broiler and market egg costs reduction will depend as much on management as on improvements in reproduction, so a prediction of actual cost benefits is difficult. Breeder chick or poult costs, however, could be reduced as much as 5¢ per bird.

Ultimately, the research advances in reproductive efficiency of poultry will benefit the consumer. These benefits will be in the form of better quality eggs and meat--at a lower price.

The potential benefits were calculated as described under III Technological Objectives on page 7.

Losses from Reproductive Deficiencies and Potential Benefit of Visualized Technology ($ Millions)

Commodity	Losses by 1988 Using Current Technology	25% Reduction of Loss	Potential Improvement by 1989
Broilers	18.8	4.7	29.6
Layers	15.6	3.9	31.3
Turkeys	5.6	1.4	8.2
	40.0	10.0	69.1
Total Benefit			79.1

F Research Effort

Agency	Current Support Year	SY	Gross ($000)	Expanded SEA—AR Support SY's SEA-AR only
SEA-AR	1978	4.5	582	6.5
SAES				
Others				
Total				
Years required for SEA-AR to achieve Visualized Technology		10		7

III.2 Improve efficiency of nutrition

A Current Technology. The principal theme of improving the technology of poultry production has been feed savings. This is reasonable since feed accounts for more than 50% of the cost of producing poultry meat and eggs. An item of this magnitude plays an important role in determining returns to producers and ultimately costs to consumers. In the U.S., 2.5 billion broilers, 200 million turkeys, and 65 billion eggs are consumed annually. This represents 30% for broilers and 20% for eggs of the world's output.

Improvements in the efficiency in which poultry utilizes its feed have been quite substantial in recent years. About 25 years ago, 7 pounds of feed were required to produce a dozen eggs; today, only 4 pounds are needed. During the past 5 years, a decrease of 1 day per year in the time required to produce a given weight broiler has occurred. This results in more efficient feed utilization since less feed is required for body maintenance. Much less improvement in the utilization of feed has occurred for turkeys and layers than that for broilers.

Credit for the improvement in feed efficiency for poultry lies in the continued emphasis on research in all phases of poultry production. In decreasing total feed consumption of poultry, two important concepts will prevail: (1) More grain (i.e., soybean meal and corn) that is utilized by poultry will be available for U.S. consumption, and (2) the consumer will benefit by decreased market cost.

Research in all phases of poultry needs to be conducted on the balance of nutrients in diets to maximize feed efficiency. This includes consideration of excesses of nutrients as well as minimum requirements for nutrients. There is very little quantitative information on the factors which may

influence breakdown and absorption, such as physical characteristics of feed ingredients, rate of passage through the digestive system, effect of methods of processing, treatment with enzymes or hormones. The feasibility of using alternative sources of ingredients, that are not consumed by humans, to improve feed utilization need to be investigated.

Feed per pound of broiler chicken: At the present time, it requires 7.6 pounds of feed and 48-55 days to produce a 3.8 pound live weight broiler chicken or 2.00 pounds of feed to produce a pound of live weight broiler chicken. This represents an improvement of 30% over the past 25-year period; however, intensive research will be necessary to continue to improve utilization of feed.

Feed per pound of turkey. Currently, approximately 3.60 pounds of feed are required to produce a pound of live weight turkey at 22-24 weeks if the breeder turkeys are included. Although turkeys have a high maintenance requirement because of their large body size, considerable improvement in feed utilization is possible.

Feed per dozen eggs: It is estimated that on a nationwide basis 4.2 pounds of feed are required to produce a dozen eggs. Considerable research is necessary to further improve utilization of feed.

The efficiency of feed utilization is dependent on the breakdown of feedstuffs into various nutrients and the absorption of these nutrients. The formulation of diets to obtain optimal ingestion, digestion, absorption, and utilization of nutrients is a complex process. The further understanding of this process involves corollary basic and applied research in physiology, biochemistry, management, genetics, and endocrinology.

B Visualized Technology. Improve efficiency of feed utilization through basic and applied research on nutrient balance, nutrient requirements, digestion, absorption and metabolism, interaction of nutrients, alternate sources of ingredients and their composition.

It is visualized that the efficiency of feed utilization will be increased during the next 10 years by these amounts:

Improve feed utilization in broiler chickens: Improvement of 10.0%, attributable directly to improvement of feed utilization.

Improve feed utilization in turkeys: Improvement of 10%, due directly to improvement of feed utilization.

Improve feed utilization in egg production: Improvement of 10%, directly attributable to improvement in feed utilization. An increase in rate of lay could increase this figure substantially.

These increases in the efficiency of feed utilization will be brought about by a multidisciplinary research approach involving nutrition, physiology, biochemistry, management, genetics, endocrinology, and others such as disease prevention and control.

C Research Approaches

1 Improve feed utilization in broiler chickens: (SR Mississippi)

a. Determine the optimum balance of nutrients to obtain maximum performance, including consideration of excesses as well as minimum requirements.

b. Determine nutrient requirements in relation to climatic conditions and environmental stress.

c. Study the effect of processing feedstuffs and diets on performance.

d. Evaluate alternate sources of protein and energy, including waste products. Emphasis will be placed on those that do not compete for human consumption.

e. Determine what percentage of individual feedstuffs is digested and absorbed (nutrient availability).

f. Evaluate the factors that influence rate of passage of feed through the digestive tract and the effect of such factors on efficiency of digestion and absorption.

g. Develop methods to increase feed intake and improve feed efficiency.

h. Study the effect of chronic and acute diseases on performance.

i. Study methods of altering metabolism and the subsequent effect on performance.

j. Study the effects of hormones on feed utilization.

k. Determine whether it is possible to develop an optimum diet for specific lines and thus improve productivity. (SR, Athens, Ga.)

2. Improve feed utilization in turkeys: (NER, Non-Ruminant Nutrition Lab, Maryland). The research approaches used for improving feed utilization in broiler chickens (C-1) apply equally to turkeys with the additions as follows:

a. Test natural feedstuffs for growth stimulants and inhibitors, for example, by comparing natural and synthetic diets.

b. Determine under what conditions antibiotics, arsenicals and other non-nutritive feed additives affect performance.

3. Improve feed utilization in egg production: (SR, Mississippi)

a. Determine the effect of growing diet on subsequent feed utilization during the laying period.

b. Determine daily nutrient requirements of essential amino acids as related to improvement in feed efficiency.

D Consequences of Visualized Technology

1. Provide an abundant supply of food of excellent nutritive value.

2. Lower the relative cost of poultry meat and eggs to consumers.

3. Reduce the cost of farm production of poultry meat and eggs.

4. Decrease pollution by producing poultry products with less waste.

5. Increase the availability of feedstuffs to man and other animals.

6. Free land currently used for the production of these feedstuffs for use in the production of food for man or other animals.

7. Make possible the expansion of a source of low cost, high quality meat and eggs for the consumer.

8. Increase consumer satisfaction and acceptability of poultry and poultry products.

9. Increase the consistency of both quality and quantity of production of poultry meat and eggs and thereby provide the producer with more consistent return.

E Potential Benefits. The proposed research will continue to improve the efficiency of poultry production. A total potential savings is difficult to determine since the poultry industry is highly specialized. There are broiler producers, broiler-breeder producers, egg producers, producers of egg layer breeders, market turkey producers, turkey breeder producers and many more. No longer is the entire process conducted on any one farm but many highly specialized production systems are required. An improvement in one area may have a chain reaction effect of improving other areas.

Results of the research will have benefit to both the large and small producer. For instance, the actual cost of producing one turkey egg with no profit has been estimated at 40¢ with two-thirds of the cost (27¢) partitioned to feed. An increase in egg production from 80 to 110 eggs per hen would reduce the feed costs per egg by spreading the cost over a greater number of eggs. For a producer with 3,000 hens, this could improve his returns approximately $3,600.

Similarly, a small improvement in feed conversion efficiency could improve economic returns. A reduction of .01 pound of feed per unit of gain for a producer raising 30,000 birds would return an additional $600. Although small, each additional .01 pound improvement returns $600 in reduced feed cost. Over 1 year, approximately $1,500 to $2,000 savings could be realized.

The potential benefit was calculated according to the procedures described under III Technological Objectives on page 7.

Losses from Nutritional Disorders and Potential Benefit of Visualized Nutrition Technology ($ Millions)

Commodity	Losses by 1988 Using Current Technology	25% Reduction of Loss	Potential Improvement by 1988
Broilers	18.8	4.7	44.2
Layers	23.6	5.9	46.9
Turkeys	5.6	1.4	12.3
	48.0	12.0	103.4
Total Benefit			115.6

F Research Effort

Agency	Year	Current Support SY	Current Support Gross ($000)	Expanded Support SY
SEA-AR	1978	5.8	801	7.8
SAES	1978			
Others	1978			
Years required for ARS to achieve Visualized Technology		10		8

III.3 Improve genetic capacity for production. In assessing the research needs for improving genetic capacity for production, the present commercial breeding activities supporting the poultry industries need to be considered. Nearly all of the breeding behind the primary poultry types (egg production chickens, meat production chickens, and turkeys) is carried out by commercial breeding organizations seeking profits on the sale of breeding stock in the form of either parent breeders, baby chicks or poults, or ready-to-lay started-pullets for egg production. Most of the commercial layers, broilers, and turkeys are produced by some system of crossbreeding, though the specific form of crossbreeding may vary between types and from organization to organization. These breeding organizations are operating under tight margins due to strong competition to obtain and maintain customers among the commercial producers. This has been especially true in egg production chickens where declining consumption of eggs and more efficient utilization of parent breeding stock through year-round placements has drastically reduced the market for parent breeding stock and thereby further increasing competition. These tight margins do not allow commercial breeders to do the fundamental research necessary to achieve improvements in the effectiveness of their breeding procedures. Thus, there is a need among these commercial breeders for basic information pertinent to new methodology for use in the future. Research along these lines will give considerable, but indirect, benefit to the producers and to the consumers of poultry products. This needed information should be in the form of actual and theoretical comparisons of procedures that might be adopted by breeding organizations.

A Current Technology. Many alternative breeding systems and breeding objectives are used by the different breeding organizations. Although considerable development and improvement of procedures have occurred over the past 30 to 40 years, there is no unanimity of agreement on the relative merits of alternative breeding systems. Since nearly all breeding stock offered for sale in the major types of poultry results from, or is used in, a crossbreeding system, there are two general approaches used by

commercial breeders to improve the stock they sell: (1) To develop and evaluate new strains to replace old strains going into the crossbreeding system; or (2) to select within each of the strains of the crossbreeding system so as to improve the efficiency of performance of the progeny.

Improvements in efficiency of egg production have occurred both through an improvement in ability to perform under adverse conditions and by increases in the number of eggs produced per hen. Greater layer densities reduce housing costs, on a per bird basis, and result in an overall increase in the efficiency of the total egg production system.

Breeding for meat production in broiler chickens and turkeys has emphasized the economic value of increasing rates of growth so as to reduce the housing costs due to time it takes to produce a specified amount of weight and to reduce the feed requirements for producing that weight. Due to difficulties encountered in producing commercial stocks, additional emphasis has been placed on retaining and, if possible, improving reproductive characteristics. In addition to increasing the rate of growth, attention has been given to fatness, feed utilization, and causes of condemnations at slaughter, including disease manifestations.

In addition to being responsible for the genetic makeup of commercial poultry, the breeding organizations also become responsible for those disease pathogens which can be transmitted from parent to offspring through the egg. Therefore, the research and production farms for breeding organizations are operated under systems of sanitation and testing considerably more stringent than commercial production facilities. This has reduced the ability of breeders to select for, and thus improve, the genetic capacity to resist diseases.

Current trends in the technology of housing and automation in both egg and meat production involve the growing of both commercial meat production stocks and layers in cages.

B Visualized Technology. Geneticists will continue to be challenged to modify the genetic characteristics so as to maintain and improve performance under the changing conditions dictated by trends in housing, automation, and management (e.g., maintaining shell quality through a long laying period sufficient to resist excessive losses due to cracks and breakage in automated egg handling). Emphasis will be placed on skeletal and anatomical characteristics necessary to support a hen's body through a lifetime of reduced activity in crowded conditions. Similar characteristics are going to be necessary and, possibly, accentuated in requirements for the heavy, fast-growing meat production birds. Increased costs of feeds due to competition with other species will make feed efficiency more important in the future. Yield and fatness will be of increased concern in the future.

The genetic capacities and potentials for production must function in the overall production systems that evolve from other areas of poultry technology so as to increase the production levels and to enhance efficiencies of the overall production systems.

Supporting this development will be enhanced knowledge of the relative merits of alternative breeding systems, so that there is a greater understanding of the appropriateness of systems available to the breeders. In some cases, different breeding systems may be necessary for different objectives and/or different sources of populations.

C Research Approaches. Research needs to be directed to six major areas.

1 Identification of Breeding Objectives. Further attention needs to be directed towards the definition of breeding objectives for the major classes of poultry. Consideration of the following economic and efficiency aspects of the industry, which are not mutually exclusive, needs to be made:

a. The relative economic importance of different traits under current conditions.

b. Anticipated economic trends likely to modify the relative economic importance of traits in the future.

c. Efficiency of utilization of feed resources.

d. Efficiency of utilization of energy resources.

Total objectives need to be decided upon relative to the insufficient oversimplified statements of objectives of the past. Even though the relative importances are likely to shift, the factors of concern for egg production, both brown and white, will be toward increased egg production at sizes and quality characteristics desired by the consumer with reduced costs of feed, housing, and reduced mortality. Emphasis in broilers will continue to be upon growth rate, but more direct attention will be paid to feed efficiency, yield, freedom from fatness and freedom from defects leading to condemnations. Special considerations in these objectives will be for production in cages and for reproduction from the parent breeding stock in cages. Considerations of meat production in turkeys will be similar to those in broilers.

2 Creation of New Breeding Populations. New populations are frequently developed as potential replacements for strains used in previous crosses to achieve superior performing crosses. In addition, new populations are developed with greater genetic variability so as to allow greater potential for genetic improvement. Many times, special genetic characteristics are desired in these new populations.

Procedures and principles need to be established for developing new populations with adequate variability for future selection programs while maintaining or protecting levels of performance. These procedures should also include methodology on incorporating single genes, such as those controlling feather-color patterns, body weight (dwarfism), and resistance to specific pathogens.

3 General Breeding Methodology. Even though attention will be paid to specific single gene effects as they are identified, efforts need to continue to be directed toward utilizing quantitative genetic variation responsible for economically important, genetically complex traits. This is the result of the many genetic influences on important physiological processes such as feed utilization, egg production, body maintenance, fat metabolism, etc. Breeding methodology will continue to involve selection where quantitative measures on candidates and their relatives will be used to arrive at decisions concerning which individuals will become parents of the next and later generations. However, estimates of physiological parameters have potential of increasing the accuracy and effectiveness of the selection program.

Alternative testing and selection schemes along with the optimum mating schemes will continue to be studied and compared. Research will be directed toward both verifying and extending the theoretical aspects of quantative inheritance so as to allow the prediction of responses to alternative breeding schemes. Especially important is the development and extension of theory to include the impact of finite population size upon long-term response to selection. Future research will be done recognizing the importance of good experimental design and the necessity of adequate replication to achieve relevant and usable experimental results.

Much of the fundamental research in this area will be done on laboratory species such as Tribolium, mice and Coturnix, but many of the principles will have to be verified on the specific poultry species. Additionally, many of the principles established on poultry species will be applicable in slower reproducing large animal species where genetic studies involving large numbers of individuals and large amounts of time are not feasible.

4 Selection Criteria. Further research into the appropriateness of selection criteria will be made emphasizing the following considerations.

a. Utilization of information regarding the appropriate traits to measure.

b. Indicator traits including the evaluation of more fundamental behavioral and physiological characteristics in addition to the direct traits of economic importance.

c. Utilization of information on sibs and progeny (purebred and crossbred) of individuals being evaluated, including response to disease exposure. (See e below)

d. Relative emphasis to be placed in selection upon component and indicator traits of overall efficiency such as

(1) relative economic importance
(2) degree of genetic control
(3) interrelationships between traits

e. Disease resistance, including procedures for evaluation of relative disease resistance without endangering the desired pathogen-free status of the primary breeding populations. This might be accomplished either by terminal exposure testing of sibs or progeny or by indirect laboratory measures. Basic research on the genetic control of immuneresponsiveness should be aimed toward developing simple selection criteria for general immuneresponsiveness to disease organisms. (See SEA-AR-NRP 20450, Control of Poultry Diseases.) Also, research effort should be directed toward assessing the relative benefits and costs of breeding for genetic resistance, vaccination to achieve resistance, and eradication to eliminate infection.

5 Systems Approach. Due to the interrelationships and interactions among the above aspects of total breeding programs, especially between selection objectives, testing schemes, mating schemes and selection criteria, considerable research is necessary concerning the overall total systems implications of these considerations.

6 Evaluation of Commercial Breeding Stocks. In addition to the above considerations of concern to improving the capabilities of the commercial breeder, evaluation of the commercial breeding stocks of egg production poultry available needs to be continued. This is necessary because of the egg producer's need to have factual information concerning the relative performance of the alternative breeding stocks and because of the difficulties and complexities of testing such stocks. Objective evaluations of egg-production stocks cannot be made by the producer as easily as for meat stocks. However, considerable modernization of the testing procedures will be necessary to sustain the validity of results of the current Random Sample Test procedures which now have reduced effectiveness due to limited numbers of test locations.

D Consequences of Visualized Technology

1. More comprehensive breeding objectives to improve overall profitability and efficiency of production systems.

2. Increased attention to important economic traits other than those prominent traits receiving considerable emphasis in the past--rate of lay in layers and rate of growth in meat stocks.

3. Greater improvements due to increased attention and more effective procedures of breeding for feed efficiency, longevity of lay, shell quality, freedom from fatness, and freedom from marketing condemnations.

4. Emphasis on adapting genetic potentials to current and future management practices of nutrition, housing, automation, and disease control which will lead to efficiencies of production systems.

E Potential Benefits. The envisioned research will continue to improve the effectiveness of breeding procedures. This, in turn, will lead to continued improvement in the economic and biological efficiency of egg and meat production. Indicative of the potential of superior breeding programs is the magnitude of present-day differences. Current random sample tests results show a 21¢ greater Income over Feed and Chick Cost for the top ten stocks relative to the average of all 34 strains tested. For even a small egg producer with 15,000 hens, this difference could improve his economic returns over $3,000. Extending this over all the nation's egg producers indicates considerable impact upon the economics of producing the nation's egg supply. These differences will be reflected in greater profits to egg producers and in reduced costs to the egg consumer. The relative efficiency of the superior stocks to the average stocks is also reflected in an average of .14 lbs. less feed per lb. of eggs for the top ten entries relative to the average of all entries. This represents a potential difference of over 1 billion lbs. less feed to produce the nation's annual egg supply. Research to allow continued creation of such potential differences in efficiency of food production merits continued support. Genetic differences of similar magnitudes also exist in the efficiencies of meat production in broiler chickens and in turkeys.

The potential benefits are calculated according to the methods described under III Technological Objectives on page 7.

Losses from Genetic Deficiencies and Potential Benefits of Visualized Genetic Improvement ($ Millions)

Commodity	Losses by 1988 Using Current Technology	25% Reduction of Loss	Potential Improvement by 1988
Broilers	28.0	7.0	44.2
Layers	15.6	3.9	31.3
Turkeys	8.0	2.0	8.2
	51.6	12.9	83.7
Total Benefit			96.6

F Research Effort

Agency	Year	Current Support SY	Current Support Gross ($000)	Expanded Support SY
SEA-AR	1978	3.9	386	5.9
SAES	1978			
Total				
Years required for SEA-AR to achieve the Visualized Technology		10		7

III.4 Improve management practices and systems

A Current Technology

1 Broiler chickens. About 75% of the annual U.S. production of broiler chickens are grown in the ten Southeastern States from Texas through North Carolina.

The typical broiler production house is 36 to 40 ft. wide and 200 to 300 ft. long, with a capacity of up to 15,000 chickens. It is of rigid-frame, clear-span construction with a sheet-metal roof and plastic-curtain sidewalls. Most have insulation in the roof, but only about one-half of the thickness of insulation considered to be optimum has been used in construction. Dirt floors are used in most houses. (See also SEA-AR-NRP 20400, Structures, Equipment and Systems for Livestock Production.)

Ventilation is usually accomplished by natural convection, controlled by manually raising or lowering sidewall curtains, although there is a trend to the use of auxiliary fans for controlling ventilation through periods of temperature extremes.

Automatic, mechanical feeders and waterers which can be raised for house cleanout are used almost universally.

Liquified petroleum gas (LPG) is the fuel used predominantly to provide heat for brooding and grow-out. Because of plentiful supply and low cost of LPG in the past, very little attention was given to energy conservation; consequently, up to 100 gallons of LPG per 1,000 chickens are commonly used to maintain the recommended brooding and rearing temperatures.

Up to five broiler houses may be concentrated on a farm, under the control of a single owner-operator. Normally, four to five batches of chickens are produced annually on each farm. However, time required to produce a batch may vary from 52 days in winter to 60 days in summer as a result of climatic temperature variations.

Typically, the catching and loading of broilers for transport to market is done by hand by a catching crew provided by the processing plant operator. The usual practice is to catch the birds at night by hand and put them in wood or plastic coops which are then hauled to the plant on a truck. The only phase of the catching-hauling operation that has been mechanized is the unloading of empty coops and reloading of filled coops on the truck. Some large, integrated producers use a lift truck for this phase of the operation.

2 Turkeys. About 70% of the U.S. turkey production is concentrated in four areas--North Central (Minnesota, Missouri, and Iowa), South Central (Texas and Arkansas), West (California), and Mid-Atlantic (Virginia and North Carolina).

The brooding and early growing phase of production is similar in all four areas. The poults are started and reared to 8 to 12 weeks in houses similar to broiler production houses. Curtain-sidewall houses are predominant in all areas except North Central, where windowless houses with mechanical ventilation are used extensively. (Also see SEA-AR-NRP 20400, Structures, Equipment and Systems for Livestock Production.)

Wide variation exists in the four areas in the finishing phase of turkey growing. Total confinement in windowless houses is used in Minnesota. About 75% of the birds in North Carolina are produced in total confinement, but the houses are of the curtain-sidewall type. In the Texas area, birds are still produced extensively on range. In California, semi-confinement rearing with open-sided shelters and outside pens is used almost exclusively. In Minnesota and California, stream pollution control regulations preclude any system that results in discharge of manure in water runoff from areas used for rearing.

Fuel requirements for the confinement phases of rearing range from about 100 gallons of LPG per 1,000 head in North Carolina to 1,000 gal/1,000 head in Minnesota.

3 Eggs. Egg production in the U.S. is widely dispersed, with very little concentration of production in specific areas. The four top egg-producting states--Georgia, California, Pennsylvania, and Arkansas--account for only 30% of total annual production.

Typically, eggs are produced in windowless, environmentally controlled houses containing from 20,000 to 30,000 caged layers per house. Feeding, watering, egg gathering, and manure removal are highly automated and mechanized. There is a trend to concentration of 25,000 or more hens on a single farm, with highly automated and mechanized egg handling, washing, grading, and packing equipment located on the same farm. (See also SEA-AR-NRP 20400, Structures, Equipment and Systems for Livestock Production.)

Most layer houses are insulated, although some do not have an adequate amount of insulation.

Evaporative cooling, with mechanical ventilation, is used extensively in the hot, arid production areas; and this cooling practice is spreading to the hot, humid areas.

Replacement pullets are floor-reared in houses similar to those used for broiler production, although there is a trend to growing of pullets in cages. Management practices and housing for replacement pullet growing are similar to those used for broiler production except that light programs are used to control sexual maturity of pullets. Continuous, low-level lighting is widely used for broilers; however, a closely controlled diurnal light program which does not increase the day length is essential for growing pullets.

4 Waste management. In the U.S. during 1976, 20 million broiler breeders produced 3 billion broilers, 1.3 million egg-type breeders produced 275 million layers, and 3.0 million turkey breeders produced 140 million turkeys. This represents an annual feed consumption of 32.2 million tons. This also represents an annual output of 32.2 million tons of poultry excreta (76% moisture) excluding bedding materials. (Also see SEA-AR-NRP 20400, Structures, Equipment and Systems for Livestock Production, and SEA-AR-NRP 20790, Preventing Pollution of and Improving the Quality of Soil, Water and Air). Unless properly treated or utilized, the excreta becomes a pollution problem creating flies and odor problems and polluting streams.

From a plant nutrient-fertilizer standpoint. fresh poultry excreta contains, on an over-dried basis, 5.5% nitrogen, 1.5% phosphorous, and 1.5% potassium with a 77% level of organic matter.

From an animal nutrient-feed standpoint, fresh poultry excreta contains 38% crude protein with 11% of the excreta being in the amino acid form, an ether extract content of 2%, a calcium level of 9%, and a phosphorous level of 2%--this on an oven-dried basis.

The common method of utilizing poultry excreta is by returning the excreta to the soil or using the excreta as a feed ingredient. With certain limitations, several states now classify poultry excreta as a feed ingredient.

One other approach is also used by the poultry industry and that is by considering poultry excreta a waste product. In the situation where economics and regulations require a waste consideration, then systems such as oxidation ditches and lagoons are used.

B Visualized Technology. It is estimated that efficiency of production will be increased during the next 10 years by these amounts:

1 Broiler chickens - Increase of 10%, primarily due to better feed conversion.

2 Turkeys - Increase of 10%, primarily due to better feed conversion.

3 Eggs - Increase of 6%, primarily due to increasing rate of lay from 235 eggs/hen/year to 275 eggs/hen/year.

These increases in productive efficiency will be made possible by advances in nutrition, genetics, and disease control, as well as advances in management. However, about one-half of the increased efficiencies will probably be attributed to management, including house and environmental control, because advances in this area have been less spectacular in the past than in the other three areas.

Visualized management research should permit the adoption of poultry production technology with these general characteristics:

1 Housing - All forms of poultry can be produced in total confinement so that light, temperature, relative humidity, and airborne pollutants and disease organisms are maintained at optimum conditions, and are relatively independent of climatic variations.

2 Waste management - Waste products from all forms of poultry production can be handled and processed for maximum reutilization of the useful components, and in such a manner that there will be no violation of applicable air and water pollution control standards.

3 Labor requirements - Mechanization and automation of feeding, watering, environmental control, product handling and processing, and waste handling and processing can reduce manual labor to a bare minimum for poultry production, with the result that labor requirements will essentially be of a technical and managerial nature.

4 Energy utilization and sources - Petroleum fuel energy requirements for all forms of poultry production can be reduced by 70%. Energy sources will be partially shifted from petroleum to solar and electrical energy for heat, and to electricity for mechanical energy. Production may shift to areas where electricity can be derived from coal and solar energy is plentiful and dependable. (This is covered in more detail in SRP, Energy Research Using Pass-Through Funds, and SEA-AR NRP 20400, Structures, Equipment and Systems for Livestock Production.)

C Research Approaches. Emphasis on applied research is required, involving the engineering, nutrition, and management disciplines, to attain the visualized technology.

Specific areas requiring concentration of effort are:

1 Housing and environment. More precise data are needed on effects of temperature, humidity, light, and airborne contaminants on productive efficiency of poultry. Interactions of these parameters with nutrition are especially important. Special emphasis should be placed on these areas for turkey and egg production. Engineering research on production facilities, especially in the areas of house construction, insulation, and heating and ventilation systems is required.

2. Waste management. It is believed that all three approaches on poultry waste must be utilized in the future to eliminate the problem; therefore, research approaches for the three areas will be considered.

As a feed ingredient, it is known that copper toxicity for sheep exists. As fertilizer to be returned to the soil, it is known that certain hazards to livestock eating grass grown on poultry excreta exist. An example is nitrate poisoning of cattle (see SEA-AR-NRP 20470, Toxicology of Chemicals and Poisonous Plants.) Maximum loading rates per acre of poultry excreta should be determined. Alternate products might be found to eliminate copper in the excreta. Therefore, the two main research approaches are:

a) To determine the deleterious effects of poultry excreta on the end product when the excreta is used as a fertilizer.

b) Determine alternate routes or products to eliminate the deleterious effects of poultry excreta when used as a fertilizer.

As a direct feed ingredient, the product must be standardized and contain no residues that will be harmful to the animal or man consuming the product. At this point, indirect methods to extract and/or convert nutrients in poultry excreta for utilization by animals should be considered. Some of the indirect conversion methods that should be considered are bacteria, fungi, insects, fish, and possibly some lower classed mammals that might thrive on poultry excreta.

If poultry excreta is considered a waste product (and under certain situations this may always be true), then ways must be found to prevent pollution of the environment. This is why work with lagoons, oxidation ditches, and floccor towers must be conducted. Also, it is possible that some of the indirect conversion methods mentioned above might be used simply to degrade the material where it is rendered pollution free.

In the research approaches, it should also be considered that dual objectives may be possible. For example, when the phosphorous shortage occurred, it might be possible to extract the phosphorous for reuse, yet treat the remainder as waste or as fertilizer. The same might be true for the amino acid nitrogen. Also, it is possible that in arid regions, lagoons can be used, yet the liquid spread through irrigation systems to surrounding pasture land.

3 Labor reduction. Functions in poultry production that require high manual labor inputs are catching and loading meat-type birds, control of environmental conditions in production houses, gathering and handling eggs, and removal and disposal of wastes. Engineering research to develop mechanization and automation of these functions is required to reduce labor inputs in poultry production.

4 Energy utilization and sources. A major engineering and management research effort is required to increase the efficiency of energy utilization in poultry production through improved housing, environmental control techniques, and management practices. Specific areas requiring intensive research are in the brooding phase of poultry growing, control of ventilation for all phases of production, and improved building insulation practices. Intensive research is needed to decrease the use of petroleum as energy.

D Consequences of Visualized Technology

1 Broiler chicken production

a. Improved housing, environmental control and management should reduce the variation in production due to climatic fluctuations so that a chicken of specific weight can be produced in a given time throughout the year. Production of a 4-lb. broiler chicken in 50 days with 6.8 lbs. of feed in both winter and summer should be possible.

b. Reduced labor requirements will result from use of automatic equipment to control environmental conditions in broiler houses, and from advances in mechanization of the catching and loading of broiler chickens at the farm.

c. Heat energy from fossil fuel, required for broiler production, should be reduced by 70%. Reduced reliance on fossil fuels as energy source should result from application of solar and other sources of energy to poultry production.

2. Turkey production. Reduced variability and risk in production should result from increased use of total confinement rearing and the gradual decline of the range system of turkey production. This trend will be assured as regulatory control pressure increases to reduce the current pollution from range turkey production systems.

3. Egg production. Seasonal variations in production should be reduced as quality of housing improves. Improvements in housing will include better insulation and tighter construction which will reduce energy requirements and reduce temperature fluctuations. Increase use of evaporative cooling will lower summer temperatures in production houses. Increased use of windowless houses will permit better light control. Improved waste management will reduce labor requirements, fly problems, and environmental pollution problems.

4. Lower the cost of production of poultry and eggs to the producer.

5. Reduce cost of poultry meat and eggs to the consumer.

6. Make possible the expansion of a source of low cost, high quality meat for the consumer.

7. Increase the consistency of both quality and quantity of production of poultry meat and eggs and thereby provide the producer with a more consistent return.

E Potential Benefits. The potential benefits were calculated as described under III Technological Objectives on page 7. In order to prevent double counting, they cover only those aspects directly attributable to poultry management. For benefits derived from the diversion of energy to other uses, e.g., manufacturing, see SEA-AR-SRP on energy pass-through funds. For the benefits from the use of poultry excreta, e.g., in ruminants see SEA-AR-NRP 20400, Structures, Equipment and Systems for Livestock Production.

Losses from Incorrect Management and Potential Benefit of Visualized Management Practices and Systems ($ millions)

Commodity	Losses by 1988 Using Current Technology	25% Reduction of Loss	Potential Improvement by 1988
Broilers	28.0	7.0	44.2
Layers	23.6	5.9	47.0
Turkeys	8.0	2.0	12.3
	59.6	14.9	103.5
Total Benefit			118.4

Other benefits from improved management techniques are difficult to quantitate economically, but include: a) Improved product quality, b) improved working conditions and less disagreeable manual labor for operators, and c) reduced environmental pollution.

F Research Effort

Agency	Year	Current Support SY	Current Support Gross ($000)	Expanded Support SY
SEA-AR	1978	1.0	107	3.0
SAES	1978			
Others				
	Total			
Years required for SEA-AR to achieve Visualized Technology		10		7

III.5 Improve efficiency of producing quality products

A Current Technology. Current production technology is well described in TO III.4, Improvement of management practices and systems. Interest in the United States and Europe continues to increase in the development of cage or coop systems for the rearing of broilers. This interest is not only stimulated by a desire to increase productivity but is demanded by the escalating costs incurred by broiler producers. During the past 10 years, most of the major problems initially encountered have been eliminated (breast blisters), mainly through system design. The single problem preventing the acceptance of a coop system by the industry is the high rate of downgrading which occurs during processing. The majority of these downgradings and condemnations are the result of broken bones, mostly wings. The solution to this problem will open an entirely new area in which the broiler industry can develop a highly efficient, easily managed operation. The product of this increased automation will be a high quality source of food.

The medical community has expressed concern over excessive consumption of lipids from animal sources. Abdominal fat in broilers amounts to about 10% of the body weight. This is a complete loss if it is produced but discarded by the housewife. Research has shown that this fat is less efficiently produced than protein. As feed is the most costly single item involved in poultry production, even a small gain in efficiency is important.

Mycotoxicosis has been shown to be a major cause of decreased efficiency of production in poultry. Some feed ingredient/mycotoxin interactions have been found to exist. Current methods of prevention, control, and detoxification are ineffective.

Losses in poultry are primarily from (a) loss from poor feed efficiency and mortality due to poor growth rate, breakdown of immune system, etc., (b) loss from condemnations, and (c) loss from downgrading due to bruising,

poor condition, etc. Research on mycotoxins in feed is covered in SEA-AR-NRP 20830, Safe Products and Processes, and research on disease aspects in SEA-AR-NRP 20420, Control of Cattle Diseases. This TO is mainly concerned with reduced quality.

Reduced product quality caused by the hemorrhagic anemia syndrome of poultry results in a substantial cost for both producers and consumers. Estimated annual cost of this condition is $198 million, based on 11 billion pounds of broiler chickens per year, and an increased cost of 1.8 cents per pound. While these production cost figures can be obtained from growth, decreased feed efficiency, mortality figures (which may be as high as 40%), and condemnation data, there is also the potential for affected birds serving as reservoirs for other diseases.

In the 20 years since this condition was first described, very little headway has been made in determining cause-effect relationships. Reports from Delaware, Massachusetts, North Carolina, Canada, England, Australia, and South Africa over the period of 1954-1974 all describe hemorrhagic lesions, liver necrosis, fatty bone marrow, and anemia in several types of poultry. These pathological observations have been hampered by a lack of knowledge regarding physiological, immunological, genetic, nutritional, and management factors which cause certain birds to be either resistant or susceptible to the agent(s) involved.

Accidental contamination of animal feedstuffs with pesticides has increased in frequency in the past several years. Estimated losses to livestock producers between 1969-1973 were greater than $3.5 million. For the broiler producer, the loss for a given flock may be 100% because all birds in the lot being marketed would be destroyed as being unfit for consumption if residues exceed tolerance limits set by FDA and EPA. (Also see (SEA-AR-NRP 20470, Toxicology and Metabolism of Agricultural Chemicals and Poisonous Plants.) Although some of the compounds (DDT, dieldrin) have been banned or restricted for general use, others such as chlordane, lindane, and heptachlor continue to be marketed.

For poultry breeders, severe financial losses have occurred with polychlorinated biphenyls (PCB's) which have severely affected hatchability of fertile eggs.

As human food supplies become scarce, losses such as those above will represent significant losses of valuable animal protein.

The affinity of the chlorinated hydrocarbons-type insecticides (i.e., DDT, dieldrin, etc.) for fatty tissue, their long-term stability, and slow rate of excretion from the body result in the retention of these compounds in the fatty tissues of the fowl long after intake of contaminated feed ceases. In the laying females, depletion of chlorinated hydrocarbons from the fatty tissue is fairly rapid because of excretion into the eggs.

However, in broilers, depletion of these compounds is limited in normal birds and most of the apparent reduction is due to a diluting effect from additional growth. Few studies have been made on the rate of accumulation or clearance of nontoxic levels of the chlorinated hydrocarbons in normal growing poultry. Little is known of how genetics, hormones, nutrition, or environmental factors may influence the rate of accumulation and clearance of these compounds in the tissues of poultry. In a practical sense, in order to decide whether or not it is economically feasible to continue feeding birds which have been exposed to contaminated feeds, the broiler or turkey grower needs information on how rapidly he can expect tissue levels to fall below the tolerance.

Studies on nutrition, pharmacological, and environmental methods to stimulate more rapid clearance of pesticides from poultry tissue are required. Although some research has shown that barbituates stimulate liver detoxification of chlorinated hydrocarbons, such techniques would not be practical or safe for commercial use. Other methods, such as the use of high carbohydrate diets which stimulate greater fat deposition and thus tend to dilute existing concentrations of the insecticide, do not solve the basic problem of actual clearance from the carcass.

B Visualized Technology. By 1988, it is anticipated that 75% of the broilers will be reared in coops. Foot problems and breast blisters will be 95% prevented and the high rate of downgrading will be reduced by 90% so that the quality of coop-reared broilers will be almost equivalent to that of broilers reared on the floor.

By a combination of genetics, nutrition, and management, the abdominal fat content of broilers will be reduced by half, i.e., to 2% of the dressed weight by 1988. The quality of the fat will be more acceptable to the consumer.

Rapid tests for mycotoxins that can be applied in field situations will be developed. Methods of prediction of conditions likely to result in toxin production will be developed so that preventative measures can be instituted. Maximum levels of toxins in feed and the finished product will be set by regulatory agencies and methods for inactivating the toxin once produced or counteracting its harmful effects will have been developed. Methods for reducing toxin production in stored feed, during distribution and in the chicken house, will be developed. This technology will decrease losses from poor feed efficiency, condemnations and downgrading by 90%.

The physiology of the chicken will be better understood so that losses from downgrading due to hemorrhagic anemia and other disturbances of the chicken's physiology can be reduced. Losses from pesticide feed contamination will be reduced by 60% in 10 years.

C Research Approaches

1. Develop technology required for the adoption of coop systems by the broiler industry. (NER)

a. Develop nutritional methods for increasing the bone strength in coop-reared broilers.

b. Determine the effect of trace elements upon the development of bone tissue.

c. Determine the influence of hormones and synthetic drugs upon bone development.

d. Measure the influence of collagen characteristics and muscle tone upon the incidence of breakage during processing.

2. Optimize factors associated with the coop system for maximizing the efficiency of broiler production. (NER)

a. Develop diets to obtain maximum performance of male and female broilers.

b. Determine the effect of environmental conditions (lighting programs, temperature programs, relative humidity, etc.) upon growth rates, feed efficiency, and condemnations.

c. Determine or develop new strains better suited for coop rearing.

d. Improve the efficiency of vaccination methods suitable for coop systems (via drinking water, aerosol).

3. Determine carcass characteristics and quality of coop-reared birds. (NER)

a. Determine dressing yield, percent parts, proximate analysis, etc.

b. Determine muscle characteristics especially in relation to the increased tenderness.

4. The following approaches will be needed to reduce the level of abdominal fat in chickens. (NER)

a. Determine the variation in abdominal fat in current stocks of broilers.

b. Determine the lipid metabolism of various levels and combinations of nutrients.

c. Determine the effects of lipid deposition of sources of energy, type of fat, energy levels and protein/calorie ratio.

d. Understand how management affects the lipid metabolism.

e. Determine the effects of dietary energy and lipid composition on other nutrient efficiencies.

5. Approaches to the reduction of losses of product quality due to mycotoxins are: (NER)

a. Understand the interaction of specific mycotoxins with various feed ingredients and their effect on feed conversion and poultry product quality.

b. Develop economic methods for preventing and reducing toxin production and for detoxifying feed.

c. Evaluate current methods for preventing mold growth and toxin elaboration for their overall benefit to poultry production.

d. Develop methods for rapid extraction, purification and identification of toxins including chromotography, electrophoresis and organ culture.

e. Determine the extent of contamination of feed ingredients by mycotoxins.

6. Develop new technology to serve as a basis for evaluating poultry production losses due to hemorrhagic anemia syndrome, determine cause effect relationships and eliminate this condition. (NER)

7. Better understand the accumulation and clearance of chlorinated hydrocarbon insecticides and similar chemicals as follows: (SEPRL, Athens, Ga.)

a. Determine normal rates and calculate prediction equations based on these results.

b. Determine the effect of sex hormones.

c. Determine the effects of genetics.

d. Determine basic excretory pathways.

e. Develop nutritional and pharmacological methods for increasing rates of excretion that would be applicable for commercial practice.

D Consequences of Visualized Technology

1. Increase the supply of high quality poultry.

2. Reduce the cost of poultry and eggs to the consumer.

3. Reduce the cost of production of poultry and eggs to the producer.

4. Increase consumer satisfaction and acceptability of poultry and poultry products.

5. Increase the quality and shelf life of broilers.

6. Reduce the microbial flow including the incidence of Salmonella in broilers.

7. Reduce the amount of fat in broilers.

8. Possible reduction in health hazard to consumer.

9. Increased efficiency of production.

10. Improve diagnostic information for poultry pathologists, scientists, and producers.

11. Eliminate anemic birds which may serve as a reservoir of other diseases.

12. Provide information for decision making by producers of poultry as to probability and length of time for clearance of insecticide residues from tissues.

13. Reduce losses due to condemnation of poultry as a result of pesticide contamination.

14. Provide basic information on metabolism and clearance of chlorinated hydrocarbons in birds.

15. Improve the quality of the product by general improvement of the sanitary conditions under which it is produced.

16. Increase the consistency of both quality and quantity of production of poultry meat and eggs and thereby provide the producer with a more consistent return.

17. Improvement in quality may increase cost to the consumer, especially in cases where it is necessary to make the product completely residue free.

E Potential Benefits. The potential benefits were calculated as described under III Technological Objectives on page 7.

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Losses from Reduced Quality and Potential Benefit from Improved Quality ($ Millions)

Commodity	Losses by 1988 Using Current Technology	25% Reduction of Loss	Potential Improvement by 1988
Broilers	18.8	4.7	14.8
Layers	15.6	3.9	31.3
Turkeys	5.6	1.4	8.2
	40.0	10.0	54.3
Total Benefit			64.3

Unmeasured benefits include greater consumer acceptability of the product and possible better health of humans consuming poultry and eggs.

F Research Effort

Agency	Year	Current Support SY	Current Support Gross ($000)	Expanded Support SY
SEA-AR	1978	2.8	323	4.8
SAES	1978			
Other	1978			
	Total			
Years required for SEA-AR to achieve Visualized Technology			10	7

III.6 Decrease losses due to diseases, pests, and other hazards

See SEA-AR-NRP 20450, Control of Poultry Diseases, and SEA-AR-NRP 20480, Control of Insects Affecting Livestock.

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V APPROVAL

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